Commercial Leverage for Lunar Exploration

PRESENTATION TO JUSTSAP

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Fundamental Change for NASA

Apollo Model

From NASA as **the** customer funding prime contractors on a cost plus fixed fee basis

Increased Private Sector Resources

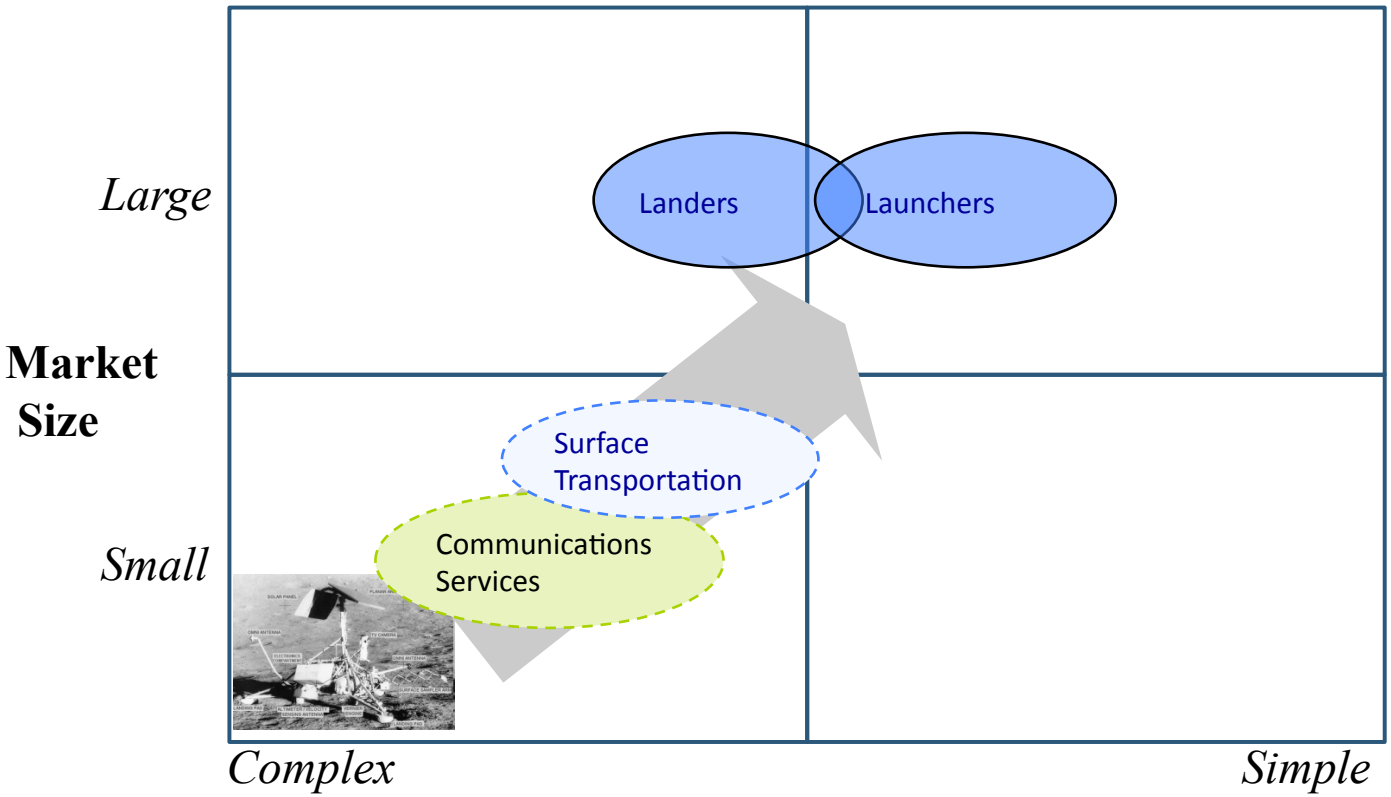
Commercial –(COTS/ CRS) Model

To NASA as a customer and partner, working with other customers, financiers, and emerging space companies on fixed price basis to secure capabilities, services and products

Business Model Feasibility

- The shift from small market, highly complex projects to manageable components with appeal to expanded markets enables greater commercial participation

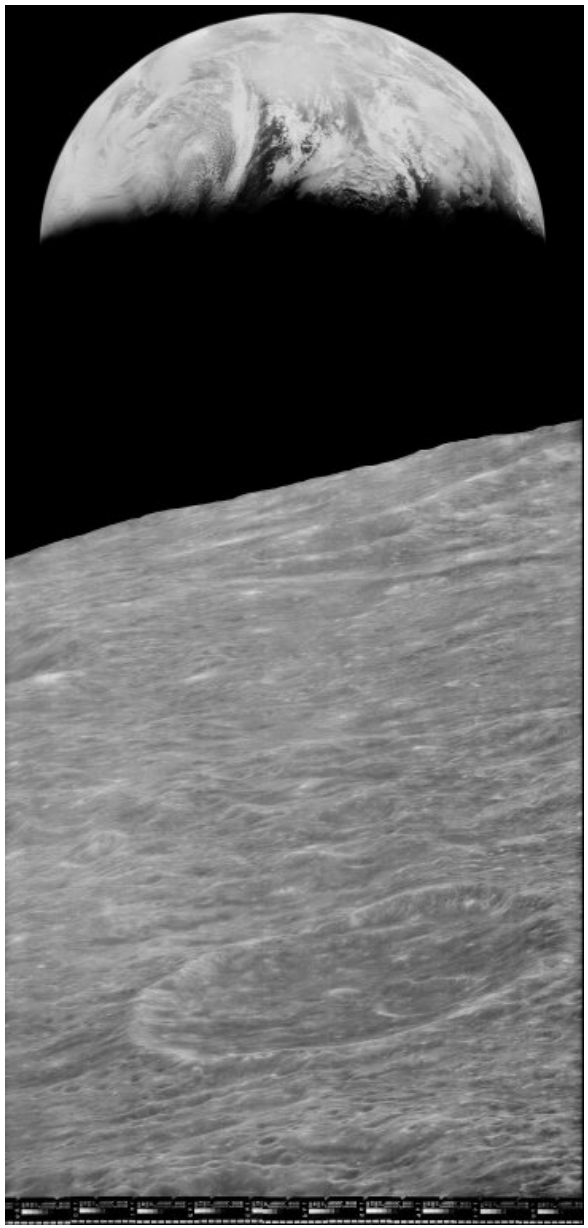
- Evolution of the Discussion -



Key drivers include:

- *Complexity*
- *Scale*
- *Timing/frequency*
- *Uncertainty*

Defining the Business Space: Beyond LEO



- **Economic sphere fairly well considered to be limited to cis-lunar**

HEO	LUNAR
Satellite servicing	Lunar data/transportation
In-space propulsion	ISRU
Propellant depots	Site surveys
Inflatable structures	Site preparation
Orbital debris removal	Lunar comm/nav

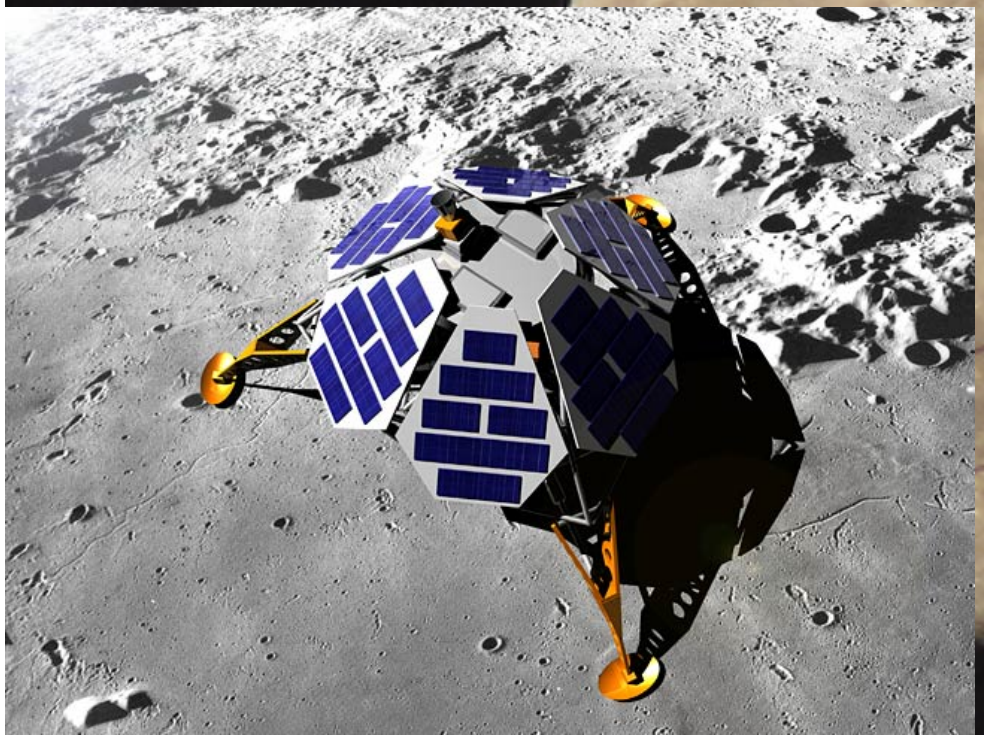
- **Some limited commercial services might exist past cis-lunar**
  - NEO: in-space propulsion, small landers

So, how do we get the ball rolling within NASA relative to the beyond-LEO commercial opportunities?

NASA "Weighs-In"

ILDD

NASA SEEKS DATA FROM INNOVATIVE LUNAR DEMONSTRATIONS



ILDD OVERVIEW

- **Data on the design and demonstration of an end-to-end lunar landing mission.**
- **This includes data associated with:**
  - hardware design,
  - development and testing;
  - ground operations and integration;
  - launch;
  - trajectory correction maneuvers;
  - lunar braking,
  - burn and landing;
  - and enhanced capabilities.

Widest Range of Offerors

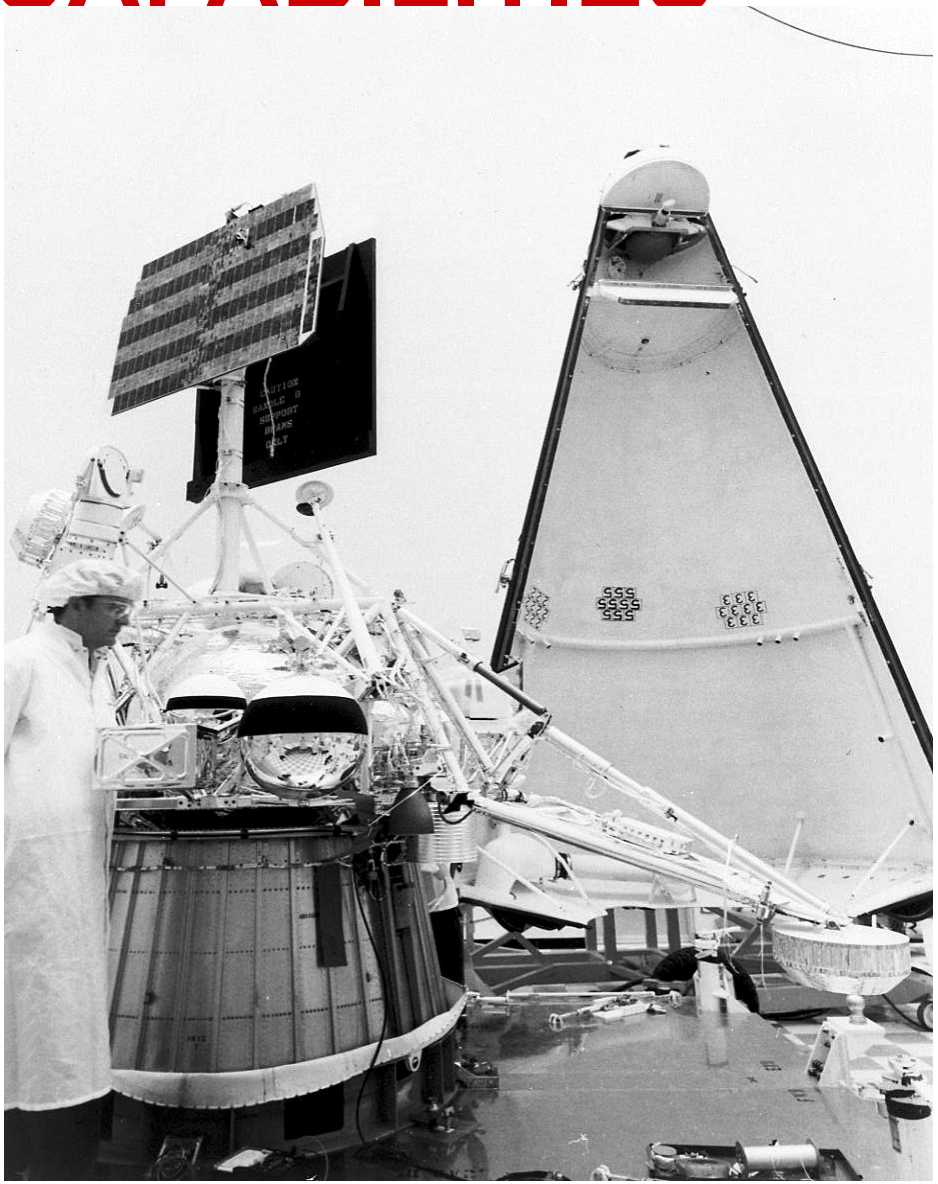
- **BAA was a "full & open" competition**
  - inviting widest range of offerors:
    - –commercial, university, foreign.
  - It was not limited to Google Lunar X-Prize.
- **NASA centers prohibited from proposing**
  - interest stems from lander data outside NASA/field centers.
- **Foreign participation allowed per the FAR supplement (1835)**
  - …participation under a "no exchange of funds" policy.

ILDD BAA Business Approach

- **Multiple small firm-fixed price, indefinite-delivery/indefinite-quantity contracts**
- **Total value up to $30.1 million up to 5 yrs**
- **$10 million max per company**
- **Partitioned into 4 contract phases**
  1. Critical Component Demonstration
  2. Ground Test/Mission Simulation of Flight Hardware
  3. Basic Capabilities of lunar landing mission
  4. Enhanced Capabilities

ILDD LANDER
BASIC CAPABILITIES

1.Prelaunch readiness of the flight spacecraft systems



ILDD LANDER
BASIC CAPABILITIES

2. In-Flight Activities

ILDD LANDER
BASIC CAPABILITIES

3. Spacecraft lunar landing

Enhanced Lander Capabilities

- **Information beneficial in risk-reduction to a human lunar lander design and capability**
  - landing using a human mission profile
  - identification of hazards during landing
  - precision landing
  - imagery
  - long-duration surface operations.

ILDD Awarded Companies

ILDD	GLXP TEAM	LOGO
Moon Express	**Moon Express** privately funded lunar transportation and data services company in San Francisco	
Earth Rise	**Omega Envoy** •*University of Central Florida (UCF)* •Embry Riddle Aeronautical University	
Astrobotic	**Astrobotic** *Carnegie Mellon University, Lockheed Martin Space Systems, Aerojet*	

ILDD Awarded Companies

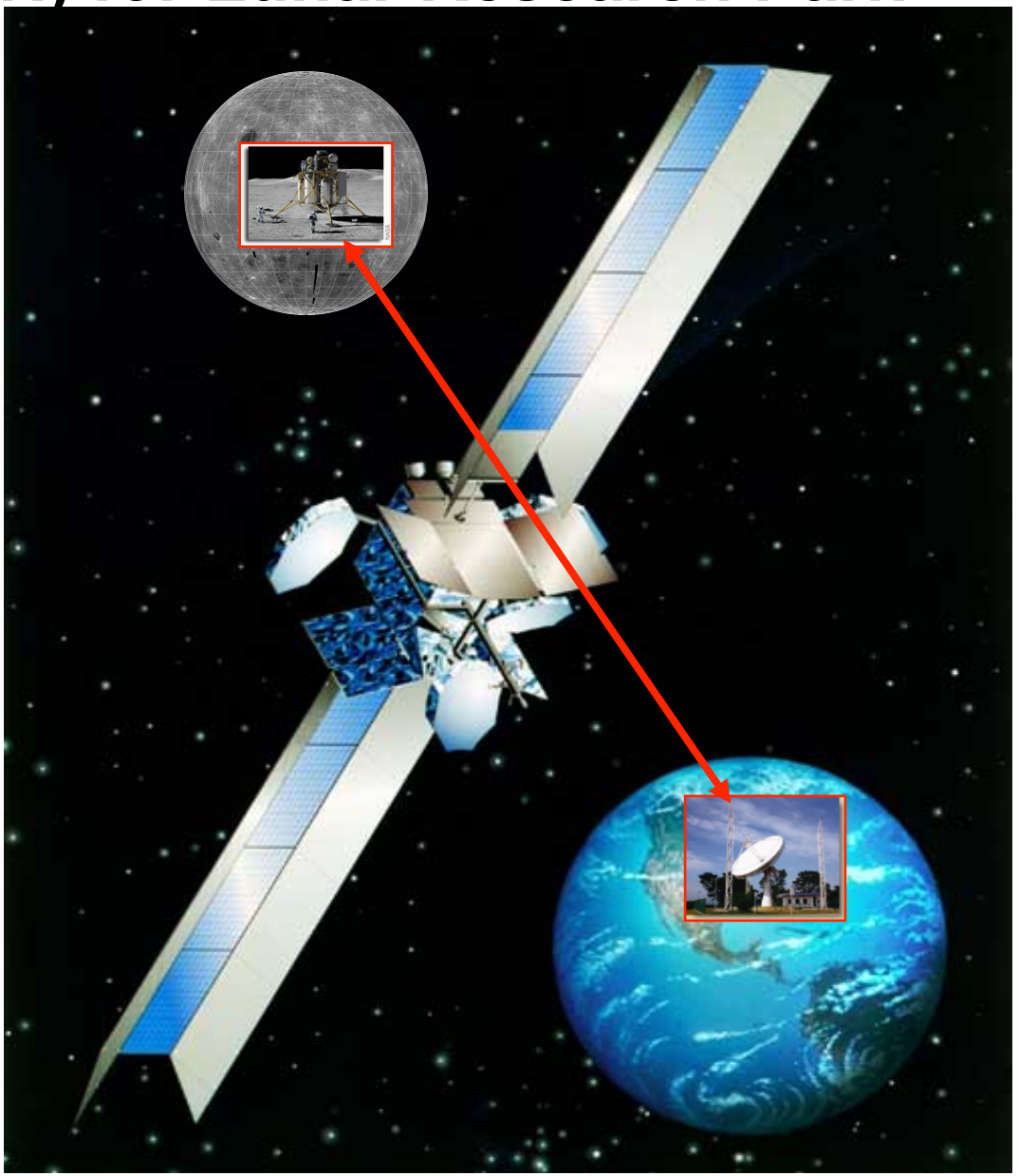
ILDD	GLXP TEAM	LOGO
Draper	**Next Giant Leap** Charles Stark Draper Laboratory (lead), Inc, Sierra Nevada Corporation, Massachusetts Institute of Technology	
Dynetics	**Rocket City Space Pioneers** Dynetics,Teledyne Brown Engineering, Andrews Space, Spaceflight Services, Draper	
Team FredNet	**Team FredNet** Open source collaboration	

Other Possible Commercial Lunar Services Applications

LUNAR COMMUNICATIONS AND NAVIGATION

Commercial Lunar Communications & Navigation (C&N) for Lunar Research Park

- Lunar C&N is a good candidate for commercial service provider(s)
- The aggregate C&N portfolio (demand) will grow over the decades
- Early commercial C&N capability could demonstrate reliability & build confidence



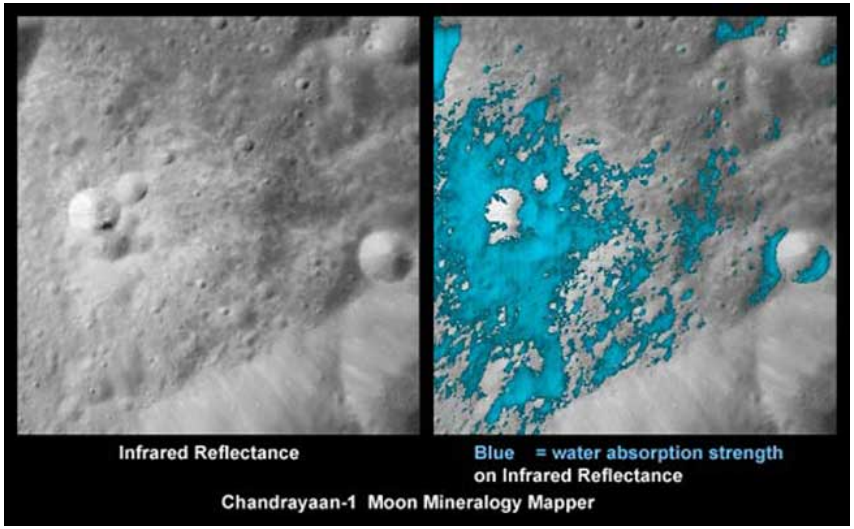
Commercial Lunar Communications Opportunities

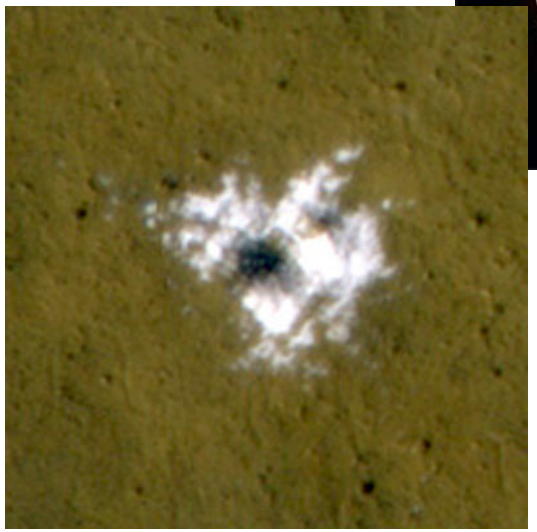
- **Lunar orbit**
  - Conventional relay services, i.e., similar to Earth-orbiting
  - Extensions to NASA-provided "essential C&N"
    - More satellites – capacity, location
    - High rate services – especially HDTV
    - Secondary payloads
    - IP-routed services & network applications
- **Lunar surface**
  - WLAN & high rate services
  - Ties into services that ride on communications – entertainment, news, scientific support, historical recording
- **Earth-based**
  - Ground stations – augment / replace portions of DSN
  - Value-added services
- **International collaboration – aiming for open, standards-based, commercially & internationally interoperable architecture**

In-Situ Resource Utilization

It's not lunacy, probes find water in moon dirt….

- **Multiple space probes found the chemical signature of water all over the moon's surface**
  - **"*this confirms that it's water and hydroxyl*" Pieters said**
- ***Questions remain….***
  - ***Where did it come from?***
  - ***What is the mechanism that it attaches to soil?***
- **Role of ISRU in answering questions…**

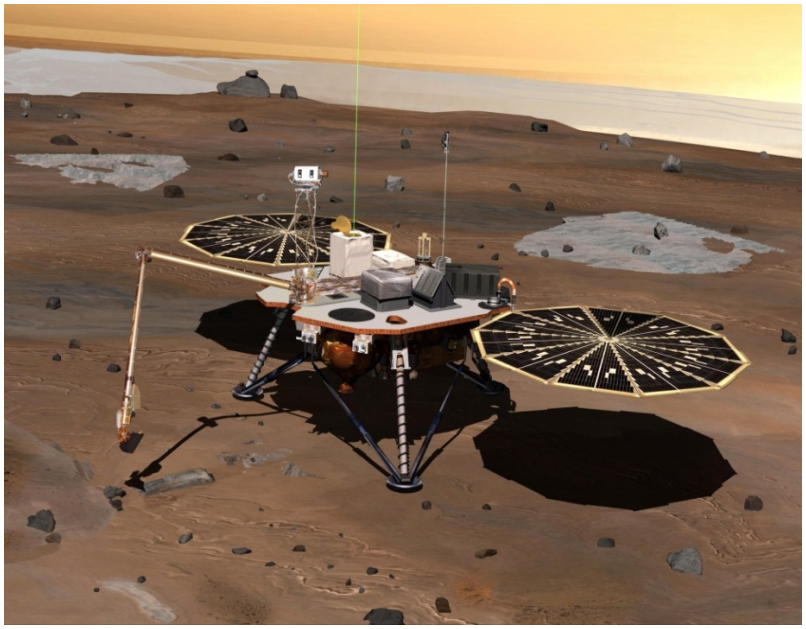




Mini-ISRU Node and Evaluation of Regolith (MINER)

Commercial Lunar Water

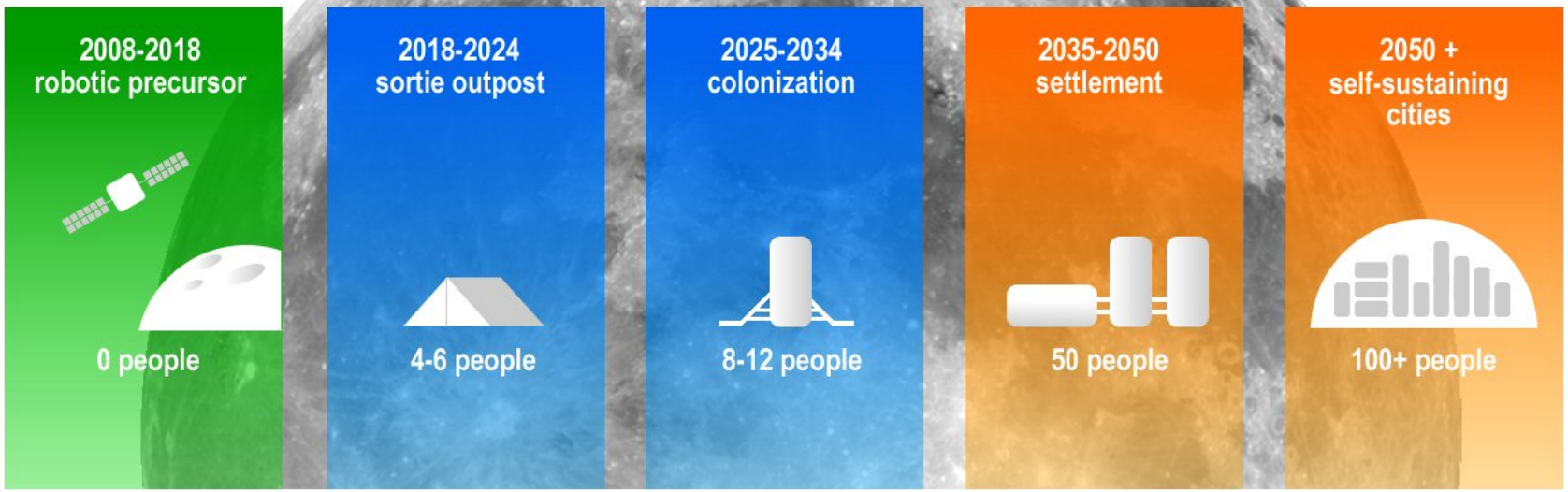
Establishing Ground-Truth



NASA & Commercial Tractor Recover Oxygen from the Lunar Regolith

INFRASTRACTURE

LUNAR ENTREPRENEURIAL OPPORTUNITIES



transportation

1. orbital habitation
2. autonomous robots
3. power storage

facilities

4. earth based research facilities
5. life support systems technology

power/comm/nav

6. solar energy
7. ground stations
8. pattern recognition software

NOTIONAL

Backup

ILDD Task Descriptions

CLIN	CLIN Title	Value ($M)
1.	Critical Component Demo	0.5
2.	Ground Test/Mission Simulation of Flight Hardware	0.6
3.	Basic Capabilities	2
3.1	Pre-launch - $0.5M	
3.2	In-Flight Activities - $0.5M	
3.3	Lunar Landing - $1M	
4.	Enhanced Capabilities	6.9
4.1	Human Mission Profile Landing - $2.5M	
4.2	Identification of Hazards During Landing - $1M	
4.3	Precision Landing - $1M	
4.4	Video Survey of Lander Post-Landing - $0.4M	
4.5	Imagery of Landing Path - $0.5M	
4.6	Participatory Exploration - $0.5M	
4.7	Extended Duration Operations - $1M	
TOTAL		10

LOFT-y Goal

- **Identify potential early "demand" for flight instrumentation for early lunar lander flights.**
- **List focuses on "orphan" flight equipment**
  - "Sunk-cost" equipment
  - Pre-exisiting
  - Flight spares, flight qual units, or engineering units
- **55 instruments identified**
  - 22 science
  - 33 technology